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Effects of Plant Mulch and Vine Care on the Growth and Yield of Cucumber (*Cucumis sativus L.*)

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ABSTRACT

Field experiments were conducted in the 2015 cropping seasons on farmer's farm, Abeokuta, Ogun State, Nigeria to study the effects of plant mulch and vine care on soil properties, leaf nutrient content, growth, and yield cucumber (*Cucumis sativus* L.). Plant mulch was applied as zero mulch (0 t ha^{-1}), *Tithonia diversifolia* (10 t ha^{-1}), *Chromolaena odorata* (10 t ha^{-1}) and vine care as no stake staked and trellised. It was a 3 x 3 factorial experiment arranged in a randomized complete block design with three replicates. Pre-experiment soil samples and soils from each plot at the end of the experiment were collected for soil physical and chemical analysis, plant growth and yield parameters were measured, and leaf nutrient analysis was carried out. Both *Tithonia* and *Chromolaena* mulches significantly ($P \leq 0.05$) reduced soil bulk density and temperature and increased soil moisture content and total porosity. They also significantly (P .≤ 0.05) increased soil OC, pH, N, P, K, Ca, Mg, leaf P, K, Ca and Mg concentrations, growth, and cucumber yield compared with the control. The application of vine care further enhanced the performance of cucumbers. Staked and trellised methods performed better than the control in most growth and yield parameters examined. Cucumber fruit yield was increased by plant mulch (*Tithonia* 84.3%, *Chromolaena* 39.7%) and vine care (trellised 54.2%, staked 26.2%) compared with control. Application of *Tithonia* mulch and trellising cucumber vines was found suitable for cucumber production

1.0. Introduction

Cucumber (*Cucumis sativus* L) is a crucial fruit vegetable crop with great nutritional, medicinal and economic potentials for man. It is a dependable food for those who suffer: constipation, duodenal ulcer, diabetics, high blood pressure and kidney ailments (Arshi, 2014). However, cucumber production in Nigeria is limited by low soil fertility, and consumer demand is affected by the fruit's shape and quality. For years, inorganic fertilizer has been advocated for crop production to ameliorate the low inherent fertility of soils in the tropics. But the use of inorganic fertilizer has not been helpful in intensive agriculture because it is expensive, scarce, often associated with soil acidity, nutrient imbalance and reduced crop yield (Abidemi *et al.* 2006, Oluwadare *et al.*, 2013). The need to use renewable forms of energy and reduce costs of fertilizing crops has revived the use of organic fertilizers worldwide (Ayoola and Adeniyan, 2006). Large quantities of organic materials such as weeds are available near farmers' fields that could be used as mulch and an effective source of nutrients for vegetables such as cucumber.

Mulching is an effective method of manipulating the crop growing environment to increase yield and improve the quality of crops by controlling weed growth, reducing soil temperature, conserving soil moisture, reducing soil erosion, improving soil structure and enhancing organic matter content of the soil (Agbede *et al.*, 2013). Mulching improves biotic activity and adds nutrients to the soil increasing soil fertility through decomposition (Awodun, 2021). The type of materials used as mulch determines its impact on soil physical and chemical properties and crop yield (Awodun, 2021). This is due to differences in the biochemical quality of plant materials. The key factors determining the quality of the mulching material are the nutrient value, texture, rate of decomposition, availability, cost, growth rate and vegetative matter turnover (Agbede *et al*., 2013). The nutritional effect of mulches on plants depends on residue quality. High-quality materials improve plant nutrition by releasing nutrients. Low-quality residues have relatively weak direct nutritional effects (Agbede *et al.,* 2013). Mulching with the residue of weeds such as Mexican sunflower (*Tithonia diversifolia)* and Siam weed (*Chromolaena odorata*) has been found to increase crop yield and soil nutrients (Awodun, 2021). This suggests that the mulches have a fertilizer effect. There is no sufficient information on the comparison of *Tithonia* and *Chromolaena* mulch as to their relative effects on soil properties, growth and yield of cucumber (Cucumis *sativus* L).

Despite all the outstanding nutritional and health potentials of cucumber, its production is still mainly in the hands of peasant farmers in Nigeria who lack information on vine care and soil management for optimum crop yield. These farmers allow the vines to trail on the ground leading to the production of fruits with yellow bellies, overcrowding of the vines and subsequent attack by mould due to high humidity. Studies have shown the importance of vine care in crop production (Pradhan *et al.*, 2021). Staking avoids overcrowding and allows correct exposure or positioning of cucumber leaves to sunlight for effective photosynthetic activities, which subsequently will enhance fruit yield.

Therefore, the study was carried out to assess the effects of:

i. Plant mulch (*Tithonia diversifolia* and *Chromolaena odorata)* on soil properties, and cucumber (*Cucumis sativus L)* growth and yield parameters.

ii. Vine care on the growth and yield parameters of cucumber (*Cucumis sativus L)* grown on (*Tithonia diversifolia* and *Chromolaena odorata*) mulched soils

iii. The interactive effect of mulch (*Tithonia diversifolia* and *Chromolaena odorata*) and vine care on the growth and yield parameters of cucumber *(Cucumis sativus L)*

2.0. Materials and Methods

2.1. Experimental Site

The experiment was located on a farmer's field at the 'camp area' (close to the Federal University of Agriculture, Abeokuta, Ogun State). Abeokuta is between 100m to 400m above sea level in the humid tropical rainforest zone of southwestern Nigeria. The mean annual rainfall is about 14000 mm, with the rainy season occurring between March and November. The rainfall distribution is bimodal, with the first season beginning from March to July and a dry spell in August followed by the second season from September to November. The average monthly relative humidity is 81%. Generally, humidity is higher in the rainy season than in the dry season. The mean monthly temperature ranges between 25.7^{o}C–30.2^{o}C (Oloruntola and Adeyemi, 2014))

2.2. Experimental Layout

The crop was grown on a raised bed in a randomized complete block design with three replicates. The size of the experimental area was 309.52 m^2 (29.2 m x 10.6 m). The size of each block (replicate) was 64.24 m$^{2.}$ Each block contained 9 plots. Each plot measured 6.16 m^2 (2.8 m x 2.2 m). The plots were separated by 0.5m space while the blocks (replicates) were separated by 1.0m alley.

2.3. Experimental Design and Treatment Combinations

The experiment was a 3 x 3 factorial design arranged in a randomized complete block design (RCBD) with three replicates. There were three types of mulch (0 t ha^{-1}, 10 t ha^{-1} *Tithonia diversifolia* and 10 t ha^{-1} *Chomolaena odorata*) and three vine care methods (no stake, staked and trellised).

2.4. Treatment Application

The mulch and vine care treatments were applied simultaneously 2 weeks after planting. The mulches were applied by placing them on the beds so that the whole beds were adequately covered. Vine care treatments were also carried out. Bamboo sticks were used as stakes, while lines (twines) attached to erected bamboo were used as trellises with the emergence of tendrils. Zero mulch and non-staked treatment was added as control

2.5. Growth and Yield Data

Six plants were randomly selected and tagged for measurement. Growth data were collected bi-weekly. The Vine length was measured as the lateral distance from the base of the shoot to the tip of the -main lateral vine by flexible tape rule. The number of leaves and number of branches per plant aswas counted. Number of harvested fruits per plant was counted at every harvest. The total number of the entire harvest was gotten by summing up the count of every harvest; fruit weight per plant was measured by using a 10 kg scale. The cumulative weights of the entire harvests were summed up for data analysis; fruit length was measured at every harvest by a flexible tape rule, fruit diameter was measured by cutting the fruit transversely into two halves, and the diameter was measured by a flexible tape rule, and fruit yield per hectare was calculated.

2.6. Soil Sampling and Analysis

Soil samples were randomly collected at the beginning of the experiment from the field, while post-harvest soil samples were collected per plot at the end of the experiment and taken to the laboratory. The soil was air-dried, crushed and sieved with a 2mm sieve mesh. It was then analyzed in the laboratory: Particle size distribution was determined by the hydrometer method (Gee and Or, 2002). Soil pH was determined in a 1.2 (soil: water) ratio using a digital electronic pH meter. Organic carbon was determined by Walkey and Black dichromate digestion method (Nelson and Sommers, 1996). Total nitrogen content was determined by the Kjeldahl digestion procedure (Bremner 1996). Available phosphorus was determined using Bray I method, and colour was developed in soil extracts using the ascorbic and acid blue colour method as outlined in Frank *et al.* (1998). Exchangeable bases (Na, K, Ca and Mg) were determined after leaching with 1 N ammonium acetate (NH_4OAC). Ca and Mg were read from the atomic absorption spectrophotometer, while K and Na were read from the flame photometer (Okalebo *et al.,* 2002).

Steel core samples were also collected from plots in triplicate, placed in an oven for 24 hours at 105^{o}C and used to determine top bulk density, gravimetric moisture content and total porosity. Total porosity was calculated from the bulk density and the particle density of $2.65 gcm^{-3}$. Gravimetric moisture content was also calculated. Soil temperature was determined at 15.00h with a soil thermometer inserted to 10cm depth. Three readings were taken at each sampling time, and the mean was computed.

2.7. Leaf Analysis

Cucumber leaf (leaves and petioles) samples were collected per plot oven-dried to constant weight, milled and analyzed for P, Ca, Mg and K according to the standard method (AOAC, 1997). P was determined by colorimetry, K was determined by flame photometry. Mg and Ca were determined by atomic absorption spectrophotometry.

2.8. Data Analysis

Data collecte**d** subjected to analysis of variance (ANOVA) using the Genstat statistical package (GENSTAT, 2007) to determine the effects of treatments on physical and chemical properties of soil, leaf nutrient content, growth and yield components of cucumber. Duncan Multiple Range Test was used to compare treatments when ANOVA has shown significant differences among means.

3.0. Results

3.1. Pre-Planting Physical and Chemical Properties of the Soil

The pre-trial physical and chemical properties of the soils of the experimental site are summarized in Table1. The texture is loamy sands**; the** pH (6.75) of the soil is within the optimum pH range for cucumber production (Valenzuela *et al*., 2005).The total nitrogen (N) ($1.4 gkg^{-1}$) of the soil fall below the critical level of < $1.8 gkg^{-1}$ for cucumber production (de Kreif *et al.,* 1992). The **a**vailable phosphorus (P) ($13.66 mg kg^{-1}$) of the soil is moderate, organic carbon ($11.80 gkg^{-1}$) is lower than the critical range ($14 – 20 gkg^{-1}$), exchangeable K ($0.27 cmolkg^{-1}$) is below the critical level (< $0.31 cmolkg^{-1}$), exchangeable Mg ($2.32 cmolkg^{-1}$) is greater than the critical level (< $1.01 cmolkg^{-1}$) and exchangeable Ca ($6.13 cm kg^{-1}$) of the soil is greater than the critical level (<$.6.0 cmolkg^{-1}$) recommended for vegetable production in Ogun State (FMRD, 2012).

3.2. Chemical Properties of Tithonia and Chromolaena Mulch Materials Used

The analysis of *Tithonia* and *Chromolaena* used for the experiment is presented in Table 2. Results indicated that *Tithonia* had higher values of N, P, K, Ca and a lower C: N ratio than *Chromolaena*. The organic C content in *Tithonia* was comparable to *Chromolaena.* Both *Tithonia* and *Chromolaena* were low in Mg. However, *Tithonia* was

Table 1: Pre-planting properties of soils of the experimental site

Soil Property	**Value**
Particle Size Analysis (gKg^{-1})	
Sand	756
Silt	144
Clay	100
Textural Class	Loamy Sand
pH (1:2) (H_2O)	6.75
Org. C (gkg^{-1})	13.7
Total N (gkg^{-1})	1.40
Available P (Bray- 1- P) ($mg kg^{-1}$)	15.66
Exchangeable Bases ($cmolkg^{-1}$)	
K	0.25
Ca	6.13
Mg	2.58
Na	0.37

Table 2: Chemical properties of Tithonia and Chromolaena mulch materials used

Property	Tithonia (a) (%)	Chromolaena (b) (%)
C	14.8	15.6
N	1.88	1.21
P	0.79	0.61
K	3.89	1.03
Ca	3.41	2.30
Mg	0.004	0.004
Na	0.15	0.44
C : N	7.8	12.9

Source: (a) Shokalu *et al*. (2010)
(b) Agbede *et al*. (2013

lower in Na than *Chromolaena*

3.3. Effect of Tithonia and Chromolaena Mulches on Soil Physical Properties at Early Rain Planting and Residual Effect at Late Rain Planting

The soil physical properties as influenced by plant mulch after cropping are presented in Table 3. *Tithonia* and *Chromolaena* mulches significantly ($P \leq 0.05$) reduced soil bulk density and temperature compared with the control (no mulch) at both plantings (Table 3). Although there were no significant differences in the values of soil bulk density and temperature of both Tithonia and Chromolaena mulch, the values of Tithonia mulch were lower than those of *Chromolaena* mulch. At both early and late rain plantings. Similarly, mulching significantly ($P \leq 0.05$) increased soil total porosity and soil moisture content compared with the control (no mulch) at both early and late rain plantings (Table 3). However, the values of total porosity and soil moisture content of *Tithonia* and *Chromolaena* mulches were statistically the same at early rain planting. Conversely, the soil moisture content of Tithonia mulch was significantly ($P < 0.05$) higher than *Chromolaena* mulch in the late rain planting.

3.4. Effect of Tithonia and Chromolaena Mulches on Soil Chemical Properties at Early Rain Planting and Residual Effect at Late Rain Planting

The soil chemical properties as affected by plant mulch after cropping are presented in Table 4

Tithonia and Chromolaena mulches significantly ($P \leq 0.05$) increased soil pH, organic carbon (O C), phosphorus (P), potassium (K), calcium (Ca) and magnesium (Mg) compared with the control (no mulch) at both early rain and late rain plantings for most of the times. Further examination revealed that in the early rain Tithonia mulched plots significantly ($P \leq 0.05$) produced higher Soil O C, N, P and K than Chromolaena mulched plots. But in the late rain, these soil nutrients were statistically the same in both Tithonia and Chromolaena mulched plots. Soil Ca of Tithonia and Chromolaena mulched plots was not significantly different at both n plantings. In addition, there were no significant differences between the mulched and un-mulched plots (control) in their values of soil pH and magnesium (Mg) at the early rain, but Tithonia and Chromolaena mulches significantly ($P \leq 0.05$) increased them compared with the control (no mulch) at late rain planting.

3.5. Effect of Tithonia and Chromolaena Mulches and Vine Care on Leaf Nutrient Content of Cucumber at Early Rain Planting and Residual Effect at Late Rain Planting

The leaf nutrient content of cucumber as influenced by plant mulch and vine care is presented in Tables 5a and 5b. Generally, mulching significantly ($P < 0.05$) increased leaf phosphorus (P), potassium (K), calcium (Ca) and magnesium (Mg) contents of cucumber compared with the control (no mulch) at both early and late rains. In the early rain, *Tithonia* mulch significantly ($P < 0.05$) increased leaf P content of cucumber more than *Chromolaena* mulch, but in late rain, there was no significant ($P < 0.05$) difference between the mulched and un-mulched plots (control) in terms of their leaf P although mulched plots still have higher values of leaf P than un-mulched plots (control). The increase in leaf Potassium (K) and Mg were statistically the same in both *Tithonia* and *Chromolaena* mulches at both early and late rains. However, the increase in leaf calcium (Ca) of *Tithonia* mulch was significantly (P <

Table 3: Effect of Tithonia and Chromolaena mulches on pre mulching and post mulching soil physical properties at early rain planting and residual effect at late rain planting

	Pre-Mulching Bulk Density gcm^{-3}	**Post - Mulching Bulk Density gcm^{-3}**	**Pre-Mulching Total Porosity %**	**Post - Mulching Total Porosity %**	**Pre – Mulching * MC %**	**Post - Mulching *M. C %**	**Pre - Mulching *S.T 0^0C**	**Post - Mulching *S. T 0^0C**
Early Rain								
No Mulch	1.34a	1.29a	49.61b	51.29b	13.33a	17.88b	36.11a	38.23a
Chromolaena	1.33a	1.16b	50.79b	56.18a	13.59a	21.43a	36.26a	33.18b
Tithonia	1.34a	1.09b	49.58b	58.77a	13.47a	21.09a	36.52a	32.87b
Late rain	←			Residual Mulching Effect				→
No Mulch	1.31a	1.33a	49.52b	49.12b	11.25b	13.29d	37.69a	39.06a
Chromolaena	1.25b	1.22b	53.01a	54.02a	12.42ab	15.92c	32.44b	33.12b
Tithonia	1.24b	1.21b	53.13a	54.00a	13.18a	16.32b	34.06b	32.52b

Means within same columns with same letters are not significantly different at $P \leq 0.05$ by DMRT * MC = Moisture content * ST = Soil Temperature

Table 4: Effect of Tithonia and Chromolaena mulches on -post-planting soil chemical properties at early rain planting and residual effect at late rain planting

	pH 1:2 (H_2O)	Org. C	N	P	K	Ca	Mg
		← gkg^{-1} →		mgkg^{-1}	← cmolkg^{-1} →		
Early Rain							
No Mulch	6.43c	16.02d	1.41c	6.43c	0.28c	7.05b	2.06b
Chromolaena	6.50c	23.39b	2.03b	10.63b	0.39b	9.11a	2.47b
Tithonia	6.43c	25.77ab	2.27a	12.39a	0.45a	9.61a	2.57b
Late rain	← Residual Mulching Effect →						
No Mulch	6.70bc	12.70d	1.11d	3.74d	0.26c	3.53e	1.94b
Chromolaena	7.12a	25.03ab	2.16ab	11.29ab	0.46a	5.31cd	5.34a
Tithonia	7.20a	27.44a	2.11ab	10.44b	0.46a	6.28c	5.21a

Means within the same columns with the same letters are not significantly different at P ≤ 0.05 by DMR

0.05) higher than that of *Chromolaena* at both early and late rains (Table 5 a).

3.6. Effect of Vine Care on Leaf Nutrient Content of Cucumber Grown on Tithonia and Chromolaena Mulched Soils at Early Rain Planting and Residual Effect At Late Rain Planting

The vine care methods (staked and trellised) significantly (P ≤ 0.05) increased leaf nutrient contents of cucumber more than the control (non-staked) except leaf P at both seasons but with a different pattern. In the early rain, trellised cucumber plants significantly (P < 0.05) produced higher leaf K and Ca contents than the staked plants. But in the late rain, there was no significant (P < 0.05) difference between values of the staked and trellised plants in their leaf K and Mg. Though the increase between staked and trellised plants was not significant, trellised plants produced higher leaf K and Mg values than staked ones at both seasons. Also, trellised plants significantly (P ≤ 0.05) increased leaf Ca content of cucumber more than staked ones at both early and late rains (Table 5 b)

3.7. Interactive Effect of Plant Mulch (Tithonia and Chromolaena) and Vine Care on Leaf Nutrient Content of Cucumber at Early Rain and Residual Effect at Late Rain Plantings

Significant (p ≤ 0.05) interactions of plant mulch and vine care were obtained in respect of leaf P, K, Ca and Mg at early rain and late rain plantings, respectively (Table 5c). In the early rain, while treatment combination of Tithonia mulch + staked produced the highest leaf P and Ca (9.10 g kg^{-1} and 21.78 g kg^{-1}) and no mulch + staked the least leaf P and Ca (6.90 g kg^{-1} and 10.37 g kg^{-1}), it was the combination of Tithonia mulch + trellised that produced the highest leaf K and Mg (21.65 g kg^{-1} and 20.75 g kg^{-1}) and no mulch + non-staked (control) the least leaf K and Mg (8.60 g kg^{-1} and 10.65 g kg^{-1}). However, in the late rain, the combination of Tithonia mulch + trellised consistently produced the highest leaf P (6.97 g kg^{-1}). K (57.47 g kg^{-1}), Ca (14.93 g kg^{-1}), and Mg (25.07 g kg^{-1}) while the control (no mulch + non staked) consistently produced the lowest leaf P (4.87 g kg^{-1}), K (27.00 g kg^{-1}), Ca (4.87 g kg^{-1}) and Mg (11.50 g kg^{-1}) respectively.

3.8. Effect of Tithonia and Chromolaena Mulches on Growth of Cucumber at Early Rain and Residual Effect at Late Rain Plantings

Mulching significantly (P ≤ 0.05) increased vine length, the number of leaves per plant and the number of branches per plant of cucumber more than the control (no mulch) at different stages of growth in both seasons (Table 6 a). At the early stage of growth (4 WAP), the vine length of *Tithonia* and *Chromolaena* mulched plants were statistically the same, but from 6 WAP to 8 WAP, the vine length of *Tithonia* mulched plants were significantly (P ≤ 0.05) longer than that of *Chromolaena*. For the number of leaves

Table 5 a: Effect of Tithonia and Chromolaena mulches on leaf nutrient content of cucumber at early rain planting and residual effect at late rain planting

	P	K	Ca	Mg
	← gkg^{-1} →			
Early Rain				
No Mulch	7.36b	11.97d	10.92c	11.44c
Chromolaena	7.00b	14.90c	12.26bc	15.97b
Tithonia	8.93a	17.96c	21.32a	16.77b
Late rain	← Residual Mulching Effect →			
No Mulch	5.87bc	31.96b	9.12d	12.89c
Chromolaena	6.63b	51.49a	10.67c	20.10ab
Tithonia	6.80b	43.27a	14.00b	22.37a

Ns = non -significant ** = significant at 1% * = significant at 5% level of probability
Means within same columns with same letters are not significantly different at P ≤ 0.05 by DMRT

Table 5 b: Effect of vine care on leaf nutrient content of cucumber grown on Tithonia and Chromolaena mulched soils at early rain planting and residual the effect at late rain plantings

	P	K	Ca	Mg
		gkg^{-1}		
Early Rain				
Non staked	7.71a	10.92e	12.88c	10.97d
Staked	7.82a	14.46de	14.63b	14.46bc
Trellised	7.76a	19.44d	16.99a	18.76ab
Late rain		Residual Effect		
Non staked	6.84b	31.41c	8.24d	16.81b
Staked	6.13b	45.01b	11.17c	17.80ab
Trellised	6.32b	50.29a	14.38b	20.74a
Season*Mulch	*	**	**	*

s = non -significant ** = significant at 1% * = significant at 5% level of probability
Means within same columns having same letters are not significantly different at P ≤ 0.05 by DMRT

per plant, although there was no significant difference between *Tithonia* and *Chromolaena* mulched plots throughout their stages of growth, yet *Tithonia* mulch produced a higher number of leaves per plant than *Chromolaena*. Also, *Tithonia* mulched plants significantly (P ≤ 0.05) produced more number branches per plant than that of *Chromolaena* at late rain only.

3.9. Effect of Vine Care on Growth of Cucumber Grown on Tithonia and Chromolaena Mulched Soils at Early Rain and Residual Effect at Late Rain Plantings

The vine care methods (staked and trellised) significantly (P ≤ 0.05) increased vine length and number of leaves per plant of cucumber compared with the control (non-staked) in both seasons (Table 6 b). Throughout the stages of growth, the vine length, number of leaves per plant and number of branches per plant of staked and trellised plants were statistically the same at both early and late rains except at 8 WAP where trellised plants significantly (P≤0.05) produced higher number of leaves per plant than staked plants. Closer observation shows that trellised plants consistently produced longer vine length, higher numbers of leaves per plant and branches per plant than the staked ones (Table 6b).

3.10. Interactive Effect of Plant Mulch (Tithonia and Chromolaena) and Vine Care on Growth of Cucumber at Early Rain and Residual Effect at Late Rain Plantings

Significant (p ≤ 0.05) interaction of plant mulch and vine care were obtained in vine length, the number of leaves per plant and the number of branches per plant at the different stages of growth (Table 6c). At the early rain planting, treatment combination of Tithonia + trellised consistently produced the longest vines (25.83 cm, 102.6 cm and 165.0 cm), the highest number of leaves per plant (17.63, 25.1 and 49.75) and the highest number of branches per plant (2.49, 7.75 and 9.1) while no mulch + non- staked (control) produced the shortest vines (18.24 cm, 72.88 cm and 120.83 cm), the lowest number of leaves per plant (6.50, 14.17 and 26.25) and lowest number of branches per plant (1.38, 4.96 and 6. 38) at 4, 6 and 8 WAP respectively. Likewise, at late rain planting treatment combination of Tithonia + trellised still produced the longest vines (27.27 cm, 119.74 cm and 160.33 cm), the highest number of leaves per plant (17.17, 25.07 and 45.07) and the highest number of branches per plant (3.53, 8.65 and 10.13) while no mulch + non- staked (control) produced the shortest vines (13.84 cm, 58.63 cm and 80.9 cm), the lowest number of leaves per plant (8.14, 16.47 and 27.47) and lowest number of branches per plant (1.38, 5.38 and 6.56) at 4, 6 and 8 WAP respectively.

3.11. Effect of Plant Mulch (Tithonia and Chromolaena) on Yield and Yield Components of Cucumber at Early Rain and Residual Effect at Late Rain Plantings

Mulching significantly (P≤0.05) increased the number and weight of fruits per plant, fruit length, fruit diameter and total fruit yield per hectare of cucumber compared with the control (no mulch) in both seasons (Table 7a). *Tithonia* mulched plants consistently produced higher numbers, heavier and bigger sized fruits and more fruits per hectare than *Chromolaena* at both early and late rains. Using the mean of the two seasons, fruit yield of cucumber was increased by Tithonia mulch 84.3% and *Chromolaena* mulch by 39.7% compared with control (no mulch)

3.12. Effect of Vine Care on Yield and Yield Components of Cucumber Grown on Tithonia and Chromolaena Muched Soils at Early Rain and Residual Effect at Late Rain Plantings

The vine care methods (staked and trellised) irrespective of the plant mulch applied significantly (P ≤ 0.05) increased weight of fruits per plant, fruit length, fruit diameter and total fruit yield per hectare compared with the control (non-staked) at both plantings except the number of fruits per plant (Table 7b). Trellised plants significantly (P ≤ 0.05) produced a higher weight of fruits per plant and total fruit yield per hectare than staked plants at early rain and late rain plantings (Table 7b). While the increase of other parameters measured haswas statistically the same between staked and trellised plants yet trellised plants produced the highest values. Using the mean of both early and late rains, fruit yield of cucumber was increased by trellising method 54.2% and staking method by 26.2%.compared with control (non-staked)

3.13. Interactive Effect of Plant Mulch (Tithonia and Chromolaena) and Vine Care on Yield and Yield Components of Cucumber at Early Rain and Residual Effect at Late Rain Plantings

Significant (P ≤ 0.05) interactive effect of plant mulch and vine care was obtained in the number of fruits per plant weight of fruits per plant fruit length, fruit diameter and total fruit yield per hectare at both early rain and late rain plantings (Table 7c). At early rain, treatment combination of Tithonia + trellised produced the highest number of fruits (7.1), longest fruits (20.68 cm), biggest sized fruits (5.70 cm), heaviest weight of fruits (1.36 kg $plant^{-1}$) and the highest fruit yield per hectare (33.34 kg ha^{-1}) while control (no mulch + non staked) t produced the least number of fruits (3.93), shortest fruits (17.75 cm), smallest sized fruits (4.88 cm), lowest weight of fruits (0.62 kg $plant^{-1}$) and the lowest fruit yield per hectare (15.09 kg $plant^{-1}$). Similarly, at late rain, treatment combination of

Table 5c: Interactive effect of Tithonia and Chromolaena mulches and vine care on leaf nutrient content of cucumber at early rain planting and residual effect at late rain planting

Treatment	P	K	Ca	Mg
	←		g kg^{-1}	→
Early Rain				
No Mulch				
Non staked	7.38bc	8.60j	10.73f	10.65k
Staked	6.90c	13.87i	10.37g	11.13ij
Trellised	8.00b	15.85hi	12.15e	13.50hi
Chromolaena				
Non staked	7.57bc	12.43i	10.77f	11.00ij
Staked	7.47bc	13.37i	12.17e	17.30ef
Trellised	7.97bc	18.90g	13.83cd	19.60cde
Tithonia				
Non staked	8.60a	13.30i	20.35b	11.55ij
Staked	9.10a	16.13gh	21.37ab	17.00ef
Trellised	8.98a	21.65f	21.78a	20.75bcd
Late rain	←		Residual Mulching Effect	→
No Mulch				
Non staked	6.13c	27.00e	5.97i	11.50ij
Staked	4.87d	33.20d	7.63h	12.07ij
Trellised	6.60c	35.67d	13.77cd	15.10fg
Chromolaena				
Non staked	6.73c	38.97c	5.80i	19.47cde
Staked	6.77c	57.77a	11.77ef	18.77de
Trellised	6.40c	57.73a	14.43c	22.07bc
Tithonia				
Non staked	7.67bc	28.27e	12.97de	19.47cde
Staked	6.77c	44.07b	14.10cd	22.57ab
Trellised	6.97c	57.47a	14.93c	25.07a
Plant Mulch* Vine Care	*	*	**	*

Means within same columns having same letters are not significantly different at P ≤ 0.05 by DMRT

Ns = non -significant ** = significant at 1% * = significant at 5% level of probability

Table 6 a: Effect of Tithonia and Chromolaena mulches on vegetative traits of cucumber at different weeks after planting (WAP) at early rain planting and residual effect at late rain planting

	Vine Length (cm)			**Number of Leaves per Plant**			**Number of Branches per Plant**		
	WAP			**WAP**			**WAP**		
	4	**6**	**8**	**4**	**6**	**8**	**4**	**6**	**8**
Early Rain									
No Mulch	20.93b	79.20b	132.18bc	6.89b	22.58ab	37.87c	3.19b	5.36d	8.34d
Chromolaena	23.51a	86.01b	143.12ab	7.52b	23.54a	42.71ab	4.06ab	7.64b	10.60b
Tithonia	22.94a	107.21a	147.61a	7.63b	24.94a	45.44a	4.65a	8.78ab	11.78ab
Late rain	←			Residual Mulching Effect					→
No Mulch	18.80b	73.63b	101.05d	9.27b	17.10c	29.16d	3.80b	5.92c	9.92c
Chromolaena	22.82a	91.80b	128.20c	17.84a	22.09ab	42.46ab	5.05a	8.19b	11.20b
Tithonia	23.14a	102.15a	138.16abc	17.46a	21.09b	41.09b	5.48a	9.53a	12.54a

Means within same columns having same letters are not significantly different at P ≤ 0.05 by DMRT

Table 6b: Effect of vine care on vegetative traits of cucumber at different weeks after planting (WAP) at early and late rain plantings

	Vine Length (cm) WAP			Number of Leaves per Plant WAP			Number of Branches per Plant WAP		
	4	6	8	4	6	8	4	6	8
Early Rain									
Non staked	19.21c	79.07b	129.86b	7.00a	22.12a	37.76bc	3.25c	4.51b	6.41b
Staked	22.77b	92.92ab	141.00a	7.46a	24.75a	41.18a	4.20b	6.68a	9.65a
Trellised	25.41a	100. 02a	152.05a	7.57a	24.19a	47.09a	4.44b	7.59a	10.57a
Late rain									
Non staked	16.87d	75.83b	104.18c	6.89a	20.16a	36.88bc	3.71c	5.53b	7.51b
Staked	22.88b	88.23b	121.76b	7.86a	18.46a	36.17c	4.94a	7.53a	10.50a
Trellised	25.00a	103.53a	141.47a	7.89a	21.66a	39.31b	5.67a	8.58a	11.60a

Means within same columns having same letters are not significantly different at P ≤ 0.05 by DMRT

Table 6c Interactive effect of Tithonia and Chromolaena mulches on the vegetative traits of cucumber at different weeks after planting (WAP) at early rain planting and residual effect at late rain planting

Treatment	Vine Length (cm)			No of Leaves per Plant			No of Branches per Plant		
	4WAP	6WAP	8WAP	4WAP	6WAP	8WAP	4WAP	6WAP	8WAP
Early Rain									
No Mulch									
Non staked	18.24cde	72.88bc	120.83efgh	6.50b	14.17e	26.25f	2.75e	3.92f	5.92f
Staked	22.26abcd	86.60abc	136.94cdef	7.22b	16.06de	27.11f	3.45cd	5.00de	7.00de
Trellised	24.31abc	80.75bc	147.75bcd	7.17b	18.18cde	32.25ef	3.67cd	6.30bcde	8.30bcde
Chromolaena									
Non staked	20.23bcde	83.82abc	141.48bcde	17.16a	22.77abc	39.10cde	3.42cd	5.22cde	7.22cde
Staked	24.73abc	86.07abc	150.22bc	17.61a	23.54abc	43.58abc	4.50bcd	7.44abcd	9.44abcd
Trellised	25.58ab	88.13abc	137.65cde	17.78a	24.32ab	45.44ab	4.25bcd	7.25bcd	11.25bcd
Tithonia									
Non staked	19.63cde	84.35abc	130.50cdefg	17.75a	25.05a	38.75cde	4.00bcd	5.63bcde	7.63bcde
Staked	21.30bcd	128.60a	135.83cdef	17.56a	24.65ab	42.83abc	4.64bcd	7.58abcd	10.58abcd
Trellised	25.83a	102.60ab	165.00a	17.63a	25.10a	49.75a	4.98bc	8.50ab	11.50ab
Late rain	← Residual Mulching Effect →								
No Mulch									
Non staked	13.84f	58.63c	80.97h	8.14b	16.47de	27.47f	2.75e	3.75ef	6.75ef
Staked	20.28bcde	77.63bc	105.79h	9.61b	15.08e	27.75f	3.92bcd	6.25bcde	9.25bcde
Trellised	22.27abcd	84.63abc	116.40fgh	10.06b	19.75bcde	32.25ef	4.72bcd	7.75abc	10.75abc
Chromolaena									
Non staked	19.53cde	76.60bc	108.09gh	16.03	24.00ab	43.33abc	4.22bcd	5.08bcde	7.08bcde
Staked	23.46abc	92.60abc	128.83 defg	20.27a	22.09abc	42.40abc	5.69ab	7.81abc	9.81abc
Trellised	25.47ab	106.21ab	147.69bcd	17.21a	20.17abcd	41.25abcd	5.22abc	8.69abcd	11.69abcd
Tithonia									
Non staked	17.25def	92.24abc	123.48efgh	17.50a	20.00abcd	39.83cde	4.17bcd	6.75bcd	10.75bcd
Staked	24.90abc	94.47abc	130.67cdefg	17.71a	18.21cde	38.36cde	5.22abc	7.53abc	11.53ab
Trellised	27.27a	119.74a	160.33ab	17.17a	25.07a	45.07ab	7.06a	10.30a	14.30a
Mulch* Vine Care	*	*	*	*	*	*	*	*	*

Means within same columns having same letters are not significantly different at P ≤ 0.05 by DMRT

Tithonia + trellised still produced the highest number of fruits (8.53), longest fruits (18.00 cm), biggest sized fruits (4.73 cm), heaviest weight of fruits (1.76 kg $plant^{-1}$) and the highest fruit yield per hectare (42.53 kg ha^{-1}) while the control (no mulch + non staked) produced the least number of fruits (3.23), shortest fruits (13.93 cm), smallest sized fruits (4.03 cm), lowest weight of fruits (0.31 kg $plant^{-1}$) and the lowest fruit yield per hectare (11.98 kg ha^{-1}) respectively.

3.14. Effect of Plant Mulch (Tithonia and Chromolaena) on Yield and Yield Components of Cucumber at Early Rain and Residual Effect at Late Rain Plantings

Mulching significantly (P≤0.05) increased the number and weight of fruits per plant, fruit length, fruit diameter and total fruit yield per hectare of cucumber compared with the control (no mulch) in both seasons (Table 7a). *Tithonia* mulched plants consistently produced higher numbers, heavier and bigger sized fruits and more fruits per hectare than *Chromolaena* at both early and late rains. Using the mean of the two seasons, fruit yield of cucumber was increased by Tithonia mulch 84.3% and *Chromolaena* mulch by 39.7% compared with control (no mulch)

3.15. Effect of Vine Care on Yield and Yield Components of Cucumber Grown on Tithonia and Chromolaena Muched Soils at Early Rain and Residual Effect at Late Rain Plantings

The vine care methods (staked and trellised) irrespective of the plant mulch applied significantly ($P \leq 0.05$) increased weight of fruits per plant, fruit length, fruit diameter and total fruit yield per hectare compared with the control (non-staked) at both plantings except the number of fruits per plant (Table 7b). Trellised plants significantly ($P \leq 0.05$) produced a higher weight of fruits per plant and total fruit yield per hectare than staked plants at early rain and late rain plantings (Table 7b). While the increase of other parameters measured haswas statistically the same between staked and trellised plants yet trellised plants produced the highest values. Using the mean of both early and late rains, fruit yield of cucumber was increased by trellising method 54.2% and staking method by 26.2%.compared with control (non-staked)

3.16. Interactive Effect of Plant Mulch (Tithonia and Chromolaena) and Vine Care on Yield and Yield Components of Cucumber at Early Rain and Residual Effect at Late Rain Plantings

Significant ($P \leq 0.05$) interactive effect of plant mulch and vine care was obtained in the number of fruits per plant weight of fruits per plant fruit length, fruit diameter and total fruit yield per hectare at both early rain and late rain plantings (Table 7c). At early rain, treatment combination of Tithonia + trellised produced the highest number of fruits (7.1), longest fruits (20.68 cm), biggest sized fruits (5.70 cm), heaviest weight of fruits (1.36 kg plant^{-1}) and the highest fruit yield per hectare (33.34 kg ha^{-1}) while control (no mulch + non staked) t produced the least number of fruits (3.93), shortest fruits (17.75 cm), smallest sized fruits (4.88 cm), lowest weight of fruits (0.62 kg

Table 7a: Effect of *Tithonia* and *Chromolaena* mulches on yield and yield components of cucumber at early rain planting and residual effect at late rain planting

	No of Fruit per plant	Fruit Lenght Cm	Fruit Diameter Cm	Fruit Yield per Plant Kg Plant^{-1}	Fruit Yield per Hectare t ha^{-1}
Early Rain					
No Mulch	4.58c	18.30a	5.08b	0.68bc	16.71c
Chromolaena	5.43b	18.57a	5.28ab	0.79b	19.30bc
Tithonia	6.01ab	19.39a	5.42a	1.02ab	25.47b
Late rain	←		Residual Mulching Effect		→
No Mulch	3.83c	14.82c	4.33c	0.64c	15.56c
Chromolaena	7.24a	16.01b	4.47c	1.10ab	25.76b
Tithonia	7.33a	16.82b	4.64bc	1.39a	34.01a

Means within same columns having same letters are not significantly different at $P \leq 0.05$ by DMRT

Table 7b: Effect of vine care on yield and yield components of cucumber at early and late rain plantings

	No of Fruit per plant	Fruit Lenght Cm	Fruit Diameter Cm	Fruit Yield per Plant Kg Plant^{-1}	Fruit Yield per Hectare t ha^{-1}
Early Rain					
Non staked	5.16a	18.09b	4.98bc	0.66c	16.17b
Staked	4.88a	18.52ab	5.19b	0.78b	19.54b
Trellised	5.99a	19.64a	5.61a	1.05ab	25.76ab
Late rain					
Non staked	5.28a	14.80d	4.33cd	0.74bc	19.79b
Staked	6.09a	16.32c	4.52c	1.05ab	25.84ab
Trellised	7.04a	16.53bc	4.59c	1.34a	29.69a

Means within same columns having same letters are not significantly different at $P \leq 0.05$ by DMRT

Table 7c: Interactive effects of Tithonia and Chromolaena mulches and vine care on yield and yield components of cucumber at early rain planting and residual effect at late rain planting

Treatment	No of Fruit per plant	Fruit Length cm	Fruit Diameter cm	Fruit Yield per Plant kg $plant^{-1}$	Fruit Yield per hectare t ha^{-1}
Early Rain					
No Mulch					
Non staked	3.93cd	17.75abcd	4.88abc	0.62cd	15.09cd
Staked	4.87abcd	18.27abcd	5.07abc	0.71bcd	17.53bcd
Trellised	4.93abcd	19.45ab	5.5ab	0.76bcd	18.71bcd
Chromolaena					
Non staked	5.03abcd	18.47abc	5.10abc	0.73bcd	17.90bcd
Staked	5.27abcd	18.83abc	5.27bc	0.80bcd	19.63bcd
Trellised	6.00abcd	18.40abc	5.47ab	0.83bcd	20.37bcd
Tithonia					
Non staked	5.43abcd	18.20abc	5.00abc	0.64cd	15.74cd
Staked	5.50abc	18.47ab	5.23ab	0.82bcd	21.46bcd
Trellised	7.10abcd	20.68a	5.78a	1.36abc	33.34abc
Late rain	← Residual Mulching Effect →				
No Mulch					
Non staked	3.23d	13.93d	4.03d	0.31e	11.98e
Staked	3.87cd	15.73bcd	4.43bc	0.70bcd	17.16bcd
Trellised	4.40bcd	14.80cd	4.53bc	0.91bcd	17.53bcd
Chromolaena					
Non staked	6.20abcd	14.77cd	4.40bc	0.91bcd	22.35bcd
Staked	7.33abc	16.47abcd	4.50bc	1.05abcd	25.93bcd
Trellised	8.20ab	16.80abcd	4.50bc	1.34abc	29.01abc
Tithonia					
Non staked	6.40abcd	15.70bcd	4.57bc	1.02abcd	25.06bcd
Staked	7.07abcd	16.77abcd	4.63bc	1.40ab	34.44ab
Trellised	8.53a	18.00abcd	4.73bc	1.76a	42.53a
Plant mulch * Vine Care	*	*	*	*	*

Means within same columns with same letters are not significantly different at $P \leq 0.05$ by DMRT. Ns = non -significant ** = significant at 1% * = significant at 5% level of probability

plant^{-1}) and the lowest fruit yield per hectare (15.09 kg plant^{-1}). Similarly, at late rain, treatment combination of Tithonia + trellised still produced the highest number of fruits (8.53), longest fruits (18.00 cm), biggest sized fruits (4.73 cm), heaviest weight of fruits (1.76 kg plant^{-1}) and the highest fruit yield per hectare (42.53 kg ha^{-1}) while the control (no mulch + non staked) produced the least number of fruits (3.23), shortest fruits (13.93 cm), smallest sized fruits (4.03 cm), lowest weight of fruits (0.31 kg plant^{-1}) and the lowest fruit yield per hectare (11.98 kg ha^{-1}) respectively.

4.0. Discussion

Response to mulching is expected because the experimental soil is low in nutrients (N, P, K and OC, FMRD, 2012) and high in bulk density. Hence, the need for soil amendment (in plant mulch) and good agricultural practices (such as vine care of cucumber plants). Both *Tithonia* and *Chromolaena* mulches improved soil physical properties by reducing soil bulk density and temperature and increasing total porosity and moisture content. Reduction in soil temperature and higher moisture content by *Tithonia* and *Chromolaena* mulches application could be attributed to the reduction of evaporation losses. Opara-Nadi and Lal (1987) also observed that surface-applied mulch at 4- 6 t ha^{-1} created more favourable soil moisture and temperature regimes than did low mulch rates or buried mulch treatments on an Alfisol of south-west Nigeria. The reduction of bulk density by both *Tithonia* and *Chromolaena* mulches could be due to an increase in organic matter, which was obtained from the degraded mulch materials by micro soilorganisms.

Organic matter is known to improve soil structure, reduce soil bulk density, enhances water infiltration and retention (Ojeniyi *et al*., 2012). The presence of vegetative surface mulches could have increased activities of beneficial soil fauna that aided organic matter decomposition. This resulted in increased soil porosity and a reduction in soil bulk density. Also, the protective cover of the mulch over the soil surface could have stabilized the soil surface against the impact of rain drop, thus preventing soil erosion, compaction and crusting (Agbede *et al*., 2013)

That both *Tithonia* and *Chromolaena* mulches increased soil O C, N, P, K, Ca and Mg compared with the control gave credence to the fact that the plant mulch treatments are rich in these nutrients. This showed that these nutrients are released into the soil by the decomposed mulches.

Similar reports by Olabode *et al.,* 2007 and Agbede *et al.*, 2013 also proved that *Tithonia* and *Chromolaena* mulches decomposed to enrich soil organic matter and nutrient concentrations. The increase of soil pH by *Tithonia* and *Chromolaena* mulches over the control (un-mulched) could be attributed to the decomposition and mineralization of the plant mulch. This led to the release of cations (like Ca, Mg) and organic matter formation that raised soil pH. This is consistent with Omotosho (2014), who reported that soil pH was increased by the application of animal manure and attributed this to the release of some cations from the decayed organic amendments. The higher values of soil O C, N, P, K, and Ca concentrations under *Tithonia* mulched plots compared with *Chromolaena* mulched plots could be adduced to the initial analysis recorded for the leaves of the two mulch materials.

The increase in leaf P, K, Ca and Mg content of cucumber was due to the increased availability of nutrients in the soil caused by the application of plant mulch. This enhanced the uptake of the nutrients by cucumber. Agbede *et al. al. al.* (2013) also recorded higher leaf N, P, K, Ca and Mg concentrations when *Tithonia* and *Chromolaena* mulches were applied to yam in Owo. Ondo State, -south-west Nigeria.

The increase in cucumber fruit production could be due to reduced soil bulk density, temperature and increased availability of soil nutrients occasioned by *Tithonia* and *Chromolaena* mulches application. This agrees with the findings of Ojeniyi *et al*. (2012) that soil under *Tithonia* and *Chromolaena* fallow improved soil structure and porosity, reduced bulk density, increased soil fertility and maize yield.

That *Tithonia* mulch produced significantly higher growth and fruit yield than *Chromolaena* mulch could be ascribed to the initial analysis recorded for the two mulch materials. *Tithonia* has higher nutrient status and a low C: N ratio compared with *Chromolaena* mulch. This could have resulted in the increased decomposition and nutrient release from *Tithonia, which enhanced cucumber nutrient uptake*. This agrees with the findings of Olabode *et al*., 2007 and Awodun, 2021 that *Tithonia* is a high-quality organic source in terms of nutrient release and supplying ability.

There were significant responses to the different vine care methods applied. Without vine caring (training), vine length and number of leaves per cucumber plant were much less. Application of vine care irrespective of plant mulch used significantly increased vine length and number of leaves per plant of cucumber. Similar responses of cucumber, tomato and fluted pumpkin to staking have been reported by (Nweke *et al.*, 2013 and Pradhan *et al*., 2021). The increase in vegetative growth could be due to upward training of cucumber vines that increased net photosynthesis. Nweke *et al.* (2013) also reported that the number of branches, leaves, vine length, and leaf area were higher in staked cucumber (Cucumis sativus L.) than in non-staked plants in Enugu, -south-east Nigeria. They suggested that the leaves on the staked plants were all exposed to greater light interception leading to a higher accumulation of photosynthates for vegetative growth. Pradhan *et al*. (2021) reported that trellis provides a better opportunity for the crop to exploit sunlight which will lead to maximum production of the vine, number of leaves and side branches that will result in better assimilation of carbohydrates.

Results of this study revealed that significant fruit quality and yield increases were obtained by vertical training of cucumber plants. This could be attributed to the reduction in fruit rot, crocked fruit, misshapen fruits, etc. Staked and trellised vine care methods (irrespective of plant mulch applied) significantly increased the number and weight of fruits, length and diameter of fruit and gave higher fruit yield per hectare compared with control. This could be attributed to the fact that vine training facilitated exposure of branches and leaves for aeration and adequate light reception as a result number of fruits increased. Alam *et al*. (2016) also found that staking increased fruit yield, reduced the proportion of unmarketable fruit, and enhanced the production of high-quality fruits of cucumber and tomato. The higher performance of trellising over staking could be attributed to the fact that sometimes wind blows off the stakes making the plants touch the ground, but string trellis are firmly attached to the soil and could not be easily blown off by the wind. Hence, trellising allowed continuous and correct positioning of cucumber leaves to sunlight for effective photosynthetic activities that enhanced increased fruit yield.

The significant plant much*vine care interactions obtained in leaf P, K, Ca, and Mg concentrations, growth and yield parameters of *Tithonia* mulch + trellised, *Tithonia* mulch + staked, *Chromolaena* mulch + trellised, and *Chromolaena* mulch + staked compared with control (no mulch + non staked) treatment combinations could be ascribed to leaves' exposure to greater light interception leading to a higher accumulation of photosynthates and proper utilization of the translocated nutrients for vegetative growth. The result may also indicate that vertical training (vine care) of cucumber plants increased growth and yield when sufficient nutrients are available in the soil.

5.0. Conclusion

Tithonia and *Chromolaena* mulches reduced soil bulk density and temperature and increased soil moisture content and total porosity, soil OC, pH, N, P, K, Ca, Mg, leaf P, K, Ca and Mg concentrations, growth and fruit yield of cucumber compared with the control. Results indicated that *Tithonia* mulch produced a significantly higher fruit yield of cucumber than *Chromolaena* mulch. The higher yield was attributed to higher N, P, K, Ca and low C: N ratio produced by *Tithonia* mulch compared with *Chromolaena* mulch. . The study also revealed that trellised mulched plants produced significantly higher fruit yields of cucumber than staked mulched plants. The increase in yield was credited to trellising vine care method used that allowed constant and correct positioning of cucumber leaves to sunlight for effective photosynthetic activities that consequently increased fruit yield. Also, the application of the cultural technique of vine care (training) further enhanced the production of higher fruit yields and quality. The treatment combination of the *Tithonia* mulch + trellised vine care method was found suitable for optimum cucumber production.

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